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Final Report: Advanced Optical Fiber Development for kW Fiber Lasers with Sub-GHz Linewidth

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5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
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6. AUTHORS

Liang Dong

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES

Clemson University
300 Brackett Hall
Box 345702
Clemson, SC 29634 -5702

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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

The project is for acquiring an optical spectrum analyzer (OSA) covering wavelength range from 1900nm to 3400nm (Yokogawa AQ6375-Z-D/FC/RFC) at a cost of $108K. This OSA is required for extending our measurement capability beyond 1.9μm, which is critical for high-power Tm-doped fiber laser development at ~2μm.

15. SUBJECT TERMS

Specialty optical fibers, optical fiber lasers

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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Report Title

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Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

The OSA has significant extended our capability to do research in MWIR and is critical for a wide range of projects including Tm-doped fiber lasers, hollow-core fiber development and MWIR source development. We have made progress across all these projects. The OSA has proven itself to be an essential tool.

Technology Transfer

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1. Executive Summary

1.1. Introduction

This proposal is for acquiring an optical spectrum analyzer (OSA) covering wavelength range from 1900nm to 3400nm (Yokogawa AQ6375-Z-D/FC/RFC) at a cost of $108K. This OSA is required for extending our measurement capability beyond 1.9μm, which is critical for high-power Tm-doped fiber laser development at ~2μm. We are currently working with ARL/AFRL to advance Tm-doped fiber lasers for their higher single-frequency power potentials, better atmosphere transmissions and eye-safe characteristics. This capability is also critical for the hollow-core fiber developments in our current JTO-MRI program (W911NF-12-1-0332), where low-loss transmission bands cover all the way from UV to 5μm. These hollow-core fibers have strong potentials not only for high-power single-mode gas fiber lasers, but also flexible deliveries for high-power optical beams from UV to well into mid-IR, providing powerful solutions for both DEW and counter-measures against IR-guided missiles. This equipment addition will significantly enhance the capabilities and effectiveness of both research and educational initiatives at Clemson University in the areas of advanced optical fiber fabrication, characterization, and high power fiber lasers in order to better serve DoD's current and future needs..

1.2. Project Status

Completed.

1.3. List of Publications/Reports

(a) Papers published in peer-reviewed journals

(b) Papers published in non-peer-reviewed journals or in conference proceedings

(c) Papers presented at meetings, but not published in conference proceedings

1.4. Scientific Personnel Supported by This Project and Honors/Wards/Degree Received

1.5. Reports of Inventions

1.6. Scientific Progress and Accomplishments

1.7. Technology Transfer, None

1.8. Copies of Technical Reports, None

2. Introduction to the Project

2.1 Statements of Objectives

This project is for acquiring an optical spectrum analyzer (OSA) covering wavelength range from 1900nm to 3400nm (Yokogawa AQ6375-Z-D/FC/RFC) at a cost of $108K.

2.2 Work Plan

2.3 Background of the Project

This proposal is for acquiring an optical spectrum analyzer (OSA) covering wavelength range from 1900nm to 3400nm (Yokogawa AQ6375-Z-D/FC/RFC) at a cost of $108K. This OSA is required for extending our measurement capability beyond 1.9μm, which is critical for high-power Tm-doped fiber laser development at ~2μm. We are currently working with ARL/AFRL to advance Tm-doped fiber lasers for their higher single-frequency power potentials, better atmosphere transmissions and eye-safe characteristics. This capability is also critical for the hollow-core fiber developments in our current JTO-MRI program (W911NF-12-1-0332), where low-loss transmission bands cover all the way from UV to 5μm. These hollow-core fibers have strong potentials not only for high-power single-mode gas fiber lasers, but also flexible deliveries for high-power optical beams from UV to well into mid-IR, providing powerful solutions for both DEW and counter-measures against IR-guided missiles. This equipment addition will significantly enhance the capabilities and effectiveness of both research and educational initiatives at Clemson University in the areas of advanced optical fiber fabrication, characterization, and high power fiber lasers in order to better serve DoD's current and future needs.

Clemson University has demonstrated significant progress under JTO-funded MRI programs towards mode area scaling of single-mode optical fibers with advanced fiber designs, leading to the recent demonstration of fibers with performance well beyond current commercial LMA and PCF fibers. Mode area scaling is critical for significant power scaling in fiber lasers. This is the first time that US domestically produced advanced fibers are taking a lead over the Europeans in this very critical area for high energy lasers.

Clemson University is also developing hollow-core optical fibers for potential single-mode high-power gas fiber lasers and optical power delivery solutions. We have made good progress in this area, demonstrating hollow-core optical fibers with low loss windows extend from visible to beyond 4μm. These hollow-core fibers have great potentials for high-power single-mode gas fiber lasers in the best atmosphere transmission windows in the mid-IR and provide revolutionary potentials for both DEW and IR counter-measures with both powerful mid-IR gas fiber lasers as well as flexible power delivery solutions. The new measurement capability provided by the required OSA is critical for the developments in this very important area, which has been dominated by the Europeans so far.

Clemson has a very strong track record of DoD funded research in optical materials and optical fibers over the past decade. Currently, we are involved in 4 JTO MRI programs on high energy lasers, with significant additional efforts in advanced optical fibers for high power fiber lasers. Novel optical fiber designs and materials are being developed in all of these programs and so the requested instrumentation is broadly applicable.

3. Status of the Project

The Optical Spectrum Analyzer (OSA) was ordered and received in 2015. The equipment is non in regular use.

4. Project highlights

5. Conclusions

The OSA has significant extended our capability to do research in MWIR and is critical for a wide range of projects including Tm-doped fiber lasers, hollow-core fiber development and MWIR source development. We have made progress across all these projects. The OSA has proven itself to be an essential tool.

6. References